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Paragraph : Section 9.2.1 Recommendation 1
Comment : Recommendation 1a which states that progressive collapse should be prevented in buildings is supported. We make the following specific comments:

1. Progressive collapse should not be considered as the same as disproportionate collapse. Progressive collapse may not be seen as disproportionate to the cause if the damage event causing it is so extreme - indeed WTC 1 and 2 suffered progressive collapse, but this was not considered disproportionate to the causal event. We offer the following commentary and definitions:

Progressive. Progressive collapse is a term to describe the spreading of the collapse of one part of the structure to other areas that were initially not touched by the damage event, such as a fire or blast. Progressive collapse occurs where one part of the structure is reliant upon the performance of other parts which then become damaged, or where the debris from the damage overloads other parts of the structure, which then collapse under this abnormal load.

Disproportionate. Disproportionate damage occurs when the consequence of the event is far greater than expected. As such, there is a link between the event witnessed and the expectation of the damage it results in, before the extent of that damage becomes known. This is about human perception and it relates not only to buildings but also to organizations.

For buildings, □small□ damage events would generally be expected to have □small□ consequences i.e. □small□ amounts of damage. Similarly, □large□ events are expected to cause large amounts of damage, particularly if the event is rare or unforeseen. A □small event□ that results in □large□ amounts of damage would be considered disproportionate.

Disproportionate damage - a definition

Damage that is more extensive than would generally be expected in consideration of the event

Progressive collapse - a definition

The spreading of the collapse of one part of the structure to other parts that were initially not affected by the damage event.

2. Design to prevent progressive collapse can be accomplished

Either :

- a) with prescriptive rules, determined with certain abnormal loading events in mind □ (such as has been the case in the UK post the 1968 Ronan-Point collapse until 2004)
- or
- b) with performance based rules, determined with certain abnormal loading events in mind which are pre-defined (eg a gas explosion of a certain magnitude, a truck impact)
- or
- c) with performance based rules, to be used with a building-specific risk assessment of the hazards.

For high-risk buildings, (c) should be the approach, with the risk assessment being shared amongst the design team and building owner/developer. However for other buildings, and as a minimum requirement for high risk buildings, it would be sensible to have the approach to abnormal loads well defined. This is required to enable the development of a common, checkable and enforceable approach. Such definition need not be prescriptive but should generally relate to accidental rather than malicious abnormal loads. The reasons for this is two fold, firstly quantifying the risk to a normal building from malicious acts both in terms of scale and probability is difficult and will vary both with building occupier and the general political climate. Secondly experience shows that designs which are resilient to accidental damage also have a degree of resilience to malicious acts.

3. Connection design is rightly identified as critical in designing for loads to be redistributed following loss of an element. Furthermore the need for ductility in connection design is identified. There is currently inadequate performance data on connections, to allow simple specification of connections that have adequate ductility to cope with the deformations expected after, say, loss of one column. Developing a standard set of connections, quantifying ductility demand and performance, are high priorities. Much can be gained from experience in seismic regions but significant differences in the amount of rotation and the post event load need to be understood.

We consider that issues (2) and (3) □ clarity on how the loads are established, and development of data related to different connection design, are the areas most in need of attention for the vast majority of building designs. Attention to these issues would give maximum benefit in terms of efficiency of design costs and construction costs whilst fulfilling the requirement for designing against progressive collapse.

Comment Reason :

Revision Suggestion : Many threats to buildings are common across the globe and many building owners are global organizations. Developing methodologies that provide uniform levels of safety across national boundaries should be

encouraged. We therefore consider that the methodologies developed should acknowledge and inform those approaches being developed elsewhere in the world.

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